



THE AMERICAN ASSOCIATION FOR
LABORATORY ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

**USAF PRIMARY STANDARDS LABORATORY
The Bionetics Corporation
Heath, OH**

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories*. This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 18 June 2005*).

Presented this 16th day of November 2006.

A handwritten signature of Peter M. Ringer over a horizontal line.

President
For the Accreditation Council
Certificate Number 2192.01
Valid to July 31, 2008



For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
& ANSI/NCSL Z540-1-1994

USAF PRIMARY STANDARDS LABORATORY
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CALIBRATION

Valid To: July 31, 2008

Certificate Number: 2192.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations¹:

I. Time and Frequency

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Frequency – Measure			
Frequency Standards and Meters	10 MHz	2.5 parts in 10^{13}	Automated frequency system from NIST with HP 5071A cesium beam
	10 MHz	1.5 parts in 10^{11}	Using HP 5071A cesium beam for typical Rubidium standard
	10 MHz	3.5 parts in 10^9	Distributed signal Agilent 53132, opt 12 counter

II. Dimensional

Parameter/Equipment	Range	Best Uncertainty ^{2,3} (\pm)	Comments
Gage Blocks – Measure			
Thin Blocks	(0.01 to 0.09375) in 0.5 mm	3 μ in 75 nm	Chrome carbide and steel blocks (English) Chrome carbide and steel blocks (Metric)
Short Blocks	(0.1 to 1) in (2 to 4) in (1 to 25) mm (30 to 100) mm	2 μ in $(1.2 + 0.7L) \mu$ in 50 nm $(46 + 0.6L)$ nm	Chrome carbide and steel blocks (English) Chrome carbide and steel blocks (Metric)
Long Blocks	(5, 6, 7, 8, 10, 12, 16, 20) in (125, 150, 175, 200, 250, 300, 400, 500) mm	$(2.4 + 0.4L) \mu$ in $(60 + 0.4L)$ nm	Steel blocks (English) Steel blocks (Metric)
Gage Block Flatness – Measure	(1 to 20) μ in	1.7 μ in	Acme Scientific AC101 or Davidson D327-101 interferometer
Angle Blocks – Measure	$45^\circ, 30^\circ, 15^\circ, 5^\circ, 3^\circ, 1^\circ$ (30, 20, 5, 3, 1) min (30, 20, 5, 3, 1) s	0.75 arc·sec	Autocollimator
Laser Frequency – Measure			
Laser Heads	Nominal		
HP 5518A	4.74×10^8 MHz	3 MHz (3.3×10^{-6}) nm	Iodine stabilized laser
ML10		12 MHz (1.6×10^{-5}) nm	

Parameter/Equipment	Range	Best Uncertainty ^{2,3} (\pm)	Comments
Plug Gages – Measure			Federal comparators, Models 130B-3, 130B-24
Outside Diameter	(0.1 to < 0.825) in (0.825 to < 5.0) in (5.0 to 11.0) in (2.54 to < 20.955) mm (20.955 to < 127) mm (127 to 279.4) mm	5.0 μ in (4.4 + 1.4L) μ in (12 + 1.4L) μ in 130 nm (120 + 1.4L) nm (310 + 1.4L) nm	
Ring Gages – Measure			Federal comparator, Model 130B-3
Inside Diameter	(0.125 to < 0.825) in (0.825 to < 1.51) in (1.51 to < 2.51) in (2.51 to < 5.0) in (5.0 to 11.0) in (3.175 to < 20.955) mm (20.955 to < 38.354) mm (38.354 to < 63.754) mm (63.754 to < 127) mm (127 to 279.4) mm	6.5 μ in 7.5 μ in 10 μ in (7.8 + 1.2L) μ in (14 + 1.3L) μ in 170 nm 200 nm 260 nm (200 + 1.2L) nm (360 + 1.3L) nm	
Angle – Measure			Dual closure with: Autocollimator, indexing tables
Polygons	0° to 360°	0.25 arc·sec	
Indexing Tables	0° to 360° (30° and 15° increments)	0.35 arc·sec	Autocollimator, polygon, indexing tables

III. Mechanical

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Sound – Measure			Brüel & Kjaer model 9699 reciprocity system with 4160 1 inch microphones
Microphone Sensitivity	250 Hz	0.10 dB	

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Vibration – Measure Accelerometer Sensitivity	(10 to 100) Hz (100 to 2500) Hz (2.5 to 10) kHz	2.3 % 2.2 % 3.1 %	Kistler 808K accelerometers with MB dynamic shaker system
Mass Comparators	(2 to 10) kg (200 to 1000) kg (20 to 100) g (1 to 10) g (1 to 500) mg 1 kg 700 g to 20 kg 250 g to 64 kg	0.027 mg 0.040 mg 0.0028 mg 0.0025 mg 0.0013 mg 0.0078 mg 5.0 mg 0.30 mg	Mettler AT 10005 Mettler AT 1005 Mettler AT 106 Mettler AT 21 Mettler UMT 6 Mettler HK 1000 MC Mettler KA 30 Mettler 64000
Pressure – Pneumatic, Absolute Measuring Equipment (Cross Float), Measure, Calibration of Piston Areas Calibration of Pressure Systems, Measure	(0.2 to 25) psi, or (1.38 to 172.37) kPa (1.7 to 100) psi, or (11.7 to 689.5) kPa (2.0 to 1000) psi, or 13.8 kPa to 6.9 MPa (0.2 to 25) psi, or (1.38 to 172.37) kPa (1.7 to 100) psi, or (11.7 to 689.5) kPa (2.0 to 1000) psi 13.8 kPa to 6.9 Mpa (0.2 to 25) psi (1.38 to 172.37) kPa (1.7 to 100) psi (11.7 to 689.5) kPa (2.0 to 1000) psi 13.8 kPa to 6.9 MPa	0.0026 % rdg + 0.18 Pa 0.0025 % rdg + 0.3 Pa 0.0043 % rdg + 1.8 Pa 0.0035 % rdg 0.0032 % rdg 0.0047 % rdg 0.0042 % rdg + 0.2 Pa 0.0039 % rdg + 0.5 Pa 0.0052 % rdg + 3 Pa	Ruska 2465 Using NIST calibrated pistons Calibration of UUT pistons with NIST calibrated pistons Calibration of UUTs (dead weight systems using piston uncertainties determined from crossfloats)

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Pressure – Hydraulic, Absolute	Measuring Equipment	0.004 % rdg + 50 Pa	DHI 7302 Using NIST calibrated pistons
	(Cross Float), Measure, Calibration of Piston Areas	0.0037 % rdg + 56 Pa	Calibration of UUT pistons with NIST calibrated pistons
	Calibration of Pressure Systems, Measure	0.0041 % rdg + 82 Pa	Calibration of UUTs (dead weight systems using piston uncertainties determined from crossfloats)
Differential Pressure – Measure	Differential Pressure Gages	0.0062 % rdg + 82 Pa	DH Instruments force balanced piston gage, Model FPG8601

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Pneumatic High Pressure –			
Measuring Equipment – Gage and Absolute	(2 to 110) MPa	0.0038 % + 69 Pa	DH Instruments PC-7202-2 using a NIST calibrated piston
Measure – Cross-Float, Calibration of Piston Areas	(2 to 110) MPa	0.0048 %	DH Instruments PC-7202-2
Measure Pressure Systems – Gage and Absolute	(2 to 110) MPa	0.0052 % rdg + 85 Pa	DH Instruments PC-7202-2
Mass – Measure, Weights and Weight Sets	(1, 2, 3, 5) mg (10, 20, 30) mg 50 mg 100 mg (200, 300) mg 500 mg 1 g 2 g 3 g 5 g 10 g 20 g 30 g 50 g 100 g 200 g 300 g 500 g 1 kg 2 kg 3 kg 5 kg 10 kg 20 kg 50 lb	1.5 μ g 1.7 μ g 1.9 μ g 2.6 μ g 2.4 μ g 2.9 μ g 4.3 μ g 4.2 μ g 4.9 μ g 6.4 μ g 11 μ g 15 μ g 20 μ g 32 μ g 61 μ g 95 μ g 130 μ g 210 μ g 62 μ g 0.48 mg 1.3 mg 1.7 mg 4.2 mg 11 mg 11 μ lb	Mettler comparator balance

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Vacuum – Measure	(0.001 to 0.01) Torr (0.01 to 0.1) Torr (0.1 to 1.0) Torr (1.0 to 10) Torr (10 to 100) Torr	0.37 % rdg + 0.35 mTorr 0.37 % rdg + 1.1 mTorr 0.69 % rdg + 0.21 mTorr 0.55 % rdg + 4 mTorr 0.59 % rdg + 49 mTorr	Capacitance manometers

IV. Thermodynamics

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Dew Point – Measure, Calibration of Hygrometers	-70 °C to +10 °C	0.6 °C	Thunder Scientific 3900
Relative Humidity – Measure, Calibration of RH Meters	5 % to 95 %	1.0 %	Thunder Scientific 9000
Temperature – Measure			
SPRTs at Fixed Points	-189.3442 °C -38.8344 °C 0.01 °C 29.7646 °C 231.928 °C 419.527 °C	2.1 mK 0.7 mK 0.4 mK 1.0 mK 1.6 mK 2.7 mK	Pond K38 cell (Ar TP) Pond K18 cell (HG TP) Jarrett TP cell (H ₂ O TP) Isotech 17402A cell (Ga MP) Isotech ITL-N-17669 cell (Sn FP) Isotech ITL-M-17671 cell (Zn FP)
SPRTs over Temperature Ranges	-200 °C to -40 °C -40 °C to 0 °C 0 °C to 420 °C 420 °C to 661 °C	2.4 mK 1.0 mK 3.7 mK 13 mK	Fixed point cells, bridge, SPRTs

V. Electrical – DC/Low Frequency

Parameter/Equipment	Range	Best Uncertainty ² (±)	Comments
DC Voltage – Measure Fixed Points	10.0 V	0.16 μV/V	Solid state reference standards (Zener) with Array Josephson junction
	10.0 V	0.54 μV/V	Zeners compared against Zeners
DC Current – Measure, Shunts	10 kΩ, 10 μA 1 kΩ, 100 μA 100 Ω, 1 mA 10 Ω, 10 mA 1 Ω, 100 mA 0.1 Ω, 1 A 0.01 Ω, 10 A/2 A 0.01 Ω, 10 A/10 A 0.001 Ω, 10 A/20 A 0.0003333 Ω, 100 A/100 A 0.0003333 Ω, 300 A/100 A	36 μΩ/Ω 51 μΩ/Ω 25 μΩ/Ω 17 μΩ/Ω 19 μΩ/Ω 7.0 μΩ/Ω 37 μΩ/Ω 45 μΩ/Ω 54 μΩ/Ω 0.011 % 60 μΩ/Ω	Measurement International resistance bridge, Guildline 9211A DC shunt

Parameter/Range	Frequency	Best Uncertainty ² (±)	Comments
AC Current – Measure, Shunts (0.01, 0.03, 0.05, 0.1, 0.3) A	40 Hz (1,5,10,20,50,100) kHz	0.06 % 0.06 %	Fluke AC current shunts A45
	40 Hz, (1,5,10,20) kHz 20 kHz	0.06 % 0.07 %	

Parameter/Range	Frequency	Best Uncertainty ² (\pm)	Comments
AC Current – Measure, Shunts (cont)			
(1.0, 3.0) A	40 Hz, (1,10,20) kHz (5,50, 100) kHz	0.06 % 0.07 %	Fluke AC current shunts A45
2.0 A	40 Hz, (1,5,10) kHz 20 kHz	0.06 % 0.07 %	
5.0 A	40 Hz, (1,5) kHz 10 & 20 kHz	0.06 % 0.07 %	
10 A	40 Hz, (1,5,10,20,50,100) kHz	0.07 % 0.07 %	
20 A	40 Hz, (1,5,10,20) kHz	0.07 %	
AC-DC Voltage Difference – Measure			
Thermal Voltage Converters			
0.5 V, 50 Ω	1 MHz 10 MHz 20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz 90 MHz 100 MHz	0.13 % 0.18 % 0.22 % 0.25 % 0.4 % 0.52 % 0.69 % 0.81 % 0.8 % 0.9 % 1.1 %	Precision measurement model EL 2030
0.5 V, 75 Ω	1 MHz 10 MHz 20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz 90 MHz 100 MHz	0.13 % 0.18 % 0.22 % 0.25 % 0.4 % 0.52 % 0.69 % 0.81 % 0.8 % 0.9 % 1.1 %	

Parameter/Range	Frequency	Best Uncertainty ² (±)	Comments
AC-DC Voltage Difference – Measure (cont) Thermal Voltage Converters 1.0 V, 50 Ω 1.0 V, 75 Ω 1.0 V, 135 Ω	1 MHz 10 MHz 20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz 90 MHz 100 MHz 1 MHz 10 MHz 20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz 90 MHz 100 MHz 1 MHz 10 MHz 20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz 90 MHz 100 MHz	0.14 % 0.16 % 0.22 % 0.27 % 0.37 % 0.52 % 0.66 % 0.82 % 0.98 % 1 % 1.1 % 0.14 % 0.16 % 0.22 % 0.27 % 0.37 % 0.52 % 0.66 % 0.82 % 0.98 % 1 % 1.1 % 0.14 % 0.16 % 0.22 % 0.27 % 0.37 % 0.52 % 0.66 % 0.82 % 0.98 % 1 % 1.1 %	Precision Measurement model EL 2030

Parameter/Range	Frequency	Best Uncertainty ² (±)	Comments
AC-DC Voltage Difference – Measure (cont)			
Thermal Voltage Converters			
1.0 V, 150 Ω	1 MHz	0.14 %	Precision Measurement Model EL 2030
	10 MHz	0.16 %	
	20 MHz	0.22 %	
	30 MHz	0.27 %	
	40 MHz	0.37 %	
	50 MHz	0.52 %	
	60 MHz	0.66 %	
	70 MHz	0.82 %	
	80 MHz	0.98 %	
	90 MHz	1 %	
	100 MHz	1.1 %	
3.0 V, 50 Ω	1 MHz	0.13 %	
	10 MHz	0.16 %	
	20 MHz	0.2 %	
	30 MHz	0.23 %	
	40 MHz	0.52 %	
	50 MHz	0.55 %	
	60 MHz	0.65 %	
	70 MHz	0.74 %	
	80 MHz	0.82 %	
	90 MHz	0.88 %	
	100 MHz	0.94 %	
3.0 V, 600 Ω	1 MHz	0.13 %	
	10 MHz	0.15 %	
	20 MHz	0.2 %	
	30 MHz	0.21 %	
	40 MHz	0.33 %	
	50 MHz	0.44 %	
	60 MHz	0.56 %	
	70 MHz	0.64 %	
	80 MHz	0.78 %	
	90 MHz	0.92 %	
	100 MHz	0.92 %	

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
DC Resistance – Measure, Fixed Points	1 Ω 10 Ω 100 Ω 1000 Ω 10 k Ω 100 k Ω 1 M Ω 10 M Ω	2.7 $\mu\Omega/\Omega$ 2.9 $\mu\Omega/\Omega$ 2.8 $\mu\Omega/\Omega$ 2.6 $\mu\Omega/\Omega$ 0.98 $\mu\Omega/\Omega$ 2.6 $\mu\Omega/\Omega$ 6.0 $\mu\Omega/\Omega$ 15 $\mu\Omega/\Omega$	Fluke 742-X w/Measurement International 6010C ESI model SR-104 w/Measurement International 6000B Fluke 742-X w/Measurement International 6000B
Inductance – Measure	100 mH	0.062 %	General Ratio Model 1689 bridge
DC Voltage, High – Measure			
0.5 V Tap	10 kV 20 kV 30 kV 40 kV 50 kV	0.0070 % 0.0073 % 0.0066 % 0.0068 % 0.0067 %	Julie Research, Model HVA 50
1 V Tap	10 kV 50 kV 75 kV 100 kV	0.0069 % 0.0072 % 0.0078 % 0.0075 %	Julie Research, Model HVA 100
10 V Tap	10 kV 50 kV 75 kV 100 kV	0.0063 % 0.0078 % 0.011 % 0.015 %	

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
AC Voltage, High – Measure 60 Hz only			
0.5 V Tap	2 kV 5 kV 10 kV 20 kV 30 kV 40 kV 50 kV	0.064 % 0.060 % 0.049 % 0.048 % 0.068 % 0.071 % 0.078 %	Julie Research, Model HVA 50
5 V Tap	2 kV 5 kV 10 kV 20 kV 30 kV 40 kV 50 kV	0.052 % 0.053 % 0.054 % 0.057 % 0.075 % 0.079 % 0.083 %	Julie Research Model HVA 50
1 V Tap	2 kV 5 kV 10 kV 15 kV (50, 75, 100) kV	0.067 % 0.054 % 0.052 % 0.053 % 0.13 %	Julie Research Model HVA 100
10 V Tap	2 kV 5 kV 10 kV 15 kV (50, 75, 100) kV	0.046 % 0.058 % 0.067 % 0.042 % 0.13 %	

Parameter/Range	Frequency	Best Uncertainty ² (\pm)	Comments
Capacitance – Measure Fixed Points			
1 pF	400 Hz 1000 Hz	10×10^{-6} pF 3.2×10^{-6} pF	Andeen Hagerling 2700A
10 pF	400 Hz 1000 Hz	31×10^{-6} pF 9.3×10^{-6} pF	
100 pF	400 Hz 1000 Hz	280×10^{-6} pF 87×10^{-6} pF	

Parameter/Range	Frequency	Best Uncertainty ² (\pm)	Comments
Peak to Peak – Measure (mV/V, 067-0625-00 Detector)	0.1 MHz (0.3, 1.0) MHz 10 MHz 30 MHz 50 MHz 100 MHz 200 MHz (300, 400) MHz 500 MHz	0.18 % 0.20 % 0.23 % 0.35 % 0.68 % 1.3 % 1.4 % 1.5 % 1.7 %	Tektronix 067-0625-00
AC Current, High – Measure			
10 A	(1, 10, 20) kHz 30 kHz 50 kHz 100 kHz	0.09 % 0.10 % 0.23 % 0.37 %	PMI EL9800, current shunts
20 A	1 kHz (10, 20) kHz 30 kHz 50 kHz 100 kHz	0.10 % 0.09 % 0.11 % 0.13 % 0.33 %	
30 A	1 kHz 10 kHz 20 kHz 30 kHz	0.09 % 0.10 % 0.12 % 0.19 %	
50 A	1 kHz (10, 20) kHz 30 kHz	0.09 % 0.14 % 0.26 %	
80 A	1 kHz 10 kHz 20 kHz	0.11 % 0.12 % 0.17 %	
100 A	1 kHz 10 kHz	0.11 % 0.25 %	

VI. Electrical – RF/Microwave

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
RF Power – Measure (Coaxial) Calibration Factors of Thermistor Mounts	0.1 MHz 0.2 MHz 0.4 MHz 0.5 MHz 1.0 MHz (2.0, 4.0) MHz (6.0, 8.0) MHz 10 MHz 10 MHz 0.01 GHz (0.05, 0.1) GHz (0.5, 1.0) GHz 1.5 GHz 2.0 GHz (2.5, 3.0) GHz 3.5 GHz 4.0 GHz 5.0 GHz 6.0 GHz 7.0 GHz 8.0 GHz 9.0 GHz 10.0 GHz 11.0 GHz 12.0 GHz 13.0 GHz (14.0, 15.0) GHz (16.0, 17.0) GHz 18.0 GHz 0.01 GHz (0.02, 0.03, 0.04) GHz 0.05 GHz (0.06, 0.07) GHz (0.08, 0.09, 0.10) GHz	3.2 % 2.7 % 3.6 % 4 % 4.3 % 4.2 % 3.9 % 3.8 % 3.9 % 3.8 % 1.0 % 1.1 % 1.2 % 1.1 % 1.2 % 1.3 % 1.3 % 1.4 % 1.3 % 1.4 % 1.3 % 1.9 % 2.0 % 2.1 % 2.0 % 2.2 % 2.1 % 1.9 % 2.8 % 0.74 % 0.76 % 0.57 % 0.64 % 0.65 %	Weinschel Engineering F1116 thermistor mount against M1111 Weinschel Engineering F1109 thermistor mount against M1111 Weinschel Engineering F1109 thermistor mount against M1110 Agilent 478A-H73 against Agilent 478A-H73

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
RF Power (cont)– Measure			
(Coaxial) Calibration Factors of Thermistor Mounts	(0.105, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55) GHz 0.60 GHz (0.65, 0.70, 0.75) GHz (0.80, 0.85, 0.90, 0.95, 1.00) GHz 1.030 GHz 1.090 GHz	1.2 % 1.3 % 1.4 % 1.5 % 1.8 % 1.8 %	Agilent 478A-H73 against Agilent 478A-H73
RF Power – Measure			Comparison of 486A against 486A/DBG-675-3
(Waveguide) Calibration Factors for Thermistor Mounts plus Couplers	(8.2 to 12.4) GHz (12.4 to 18.0) GHz (18.0 to 26.5) GHz (26.5 to 40) GHz	1.6 % 2.0 % 2.7 % 2.8 %	X-band P-band K-band R-band
(Waveguide) Calibration Factors for Thermistor Mounts	(8.2 to 12.4) GHz (12.4 to 18.0) GHz (18.0 to 26.5) GHz (26.5 to 40) GHz	2.0 % 2.6 % 4.1 % 3.7 %	Comparison of 486A/DBG-675-3 against 486A X-band P-band K-band R-band

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
RF Power, High – Measure, at 100 W Calibration Factors for RF Directional Thruline Power Sensors	Fixed Frequency Points 2 MHz 4 MHz 6 MHz 8 MHz 10 MHz 15 MHz 20 MHz 25 MHz 30 MHz (30 to 850) MHz 900 MHz 950 MHz 1000 MHz	2.8 % 2.7 % 2.8 % 2.7 % 2.9 % 3.1 % 3.0 % 2.9 % 2.9 % 4.3 % 4.5 % 4.3 % 4.6 %	Bird 4021 Bird 4022
Reflection Measurements – S11/S22, Magnitude & Phase Coaxial Type N	 (0 to 0.10) lin; (0.045 to 2.0) GHz (0 to 0.10) lin; (2.0 to 8.0) GHz (0 to 0.10) lin; (8.0 to 18.0) GHz (0.10 to 0.30) lin; (0.045 to 2.0) GHz (0.10 to 0.30) lin; (2.0 to 8.0) GHz (0.10 to 0.30) lin; (8.0 to 18.0) GHz (0.30 to 0.70) lin; (0.045 to 2.0) GHz	 0.0051 to 0.0056 (3.2 to 180) ° 0.0091 to 0.0096 (7.0 to 180) ° 0.0094 to 0.01 (9.2 to 180) ° 0.0056 to 0.0076 (1.3 to 2.95) ° 0.0097 to 0.013 (3.7 to 6.5) ° 0.01 to 0.014 (5.9 to 8.7) ° 0.0076 to 0.013 (0.9 to 3.7) °	HP 8510C, test set 8515A, source 8340B, cables 85132F, cal kit 85054B

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Reflection Measurements (cont) – S11/S22, Magnitude & Phase			
Coaxial Type N	(0.30 to 0.70) lin; (2.0 to 8.0) GHz	0.013 to 0.022 (3.1 to 3.7) °	HP 8510C, test set 8515A, source 8340B, cables 85132F, cal kit 85054B
	(0.30 to 0.70) lin; (8.0 to 18.0) GHz	0.014 to 0.027 (5.5 to 5.8) °	
	(0.70 to 1.0) lin; (0.045 to 2.0) GHz	0.013 to 0.018 (0.83 to 0.89) °	
	(0.70 to 1.0) lin; (2.0 to 8.0) GHz	0.022 to 0.031 (3.1 to 3.1) °	
	(0.70 to 1.0) lin; (8.0 to 18.0) GHz	0.027 to 0.042 (5.7 to 5.5) °	
	(0 to 0.10) lin; (0.045 to 2.0) GHz	0.0035 to 0.004 (2.3 to 180) °	
	(0 to 0.10) lin; (2.0 to 8.0) GHz	0.0036 to 0.0041 (3.9 to 180) °	
	(0 to 0.10) lin; (8.0 to 18.0) GHz	0.0048 to 0.0054 (6.0 to 180) °	
	(0.10 to 0.30) lin; (0.045 to 2.0) GHz	0.004 to 0.0059 (1.0 to 2.1) °	
	(0.10 to 0.30) lin; (2.0 to 8.0) GHz	0.0041 to 0.0063 (2.6 to 3.7) °	
Coaxial 7 mm	(0.10 to 0.30) lin; (8.0 to 18.0) GHz	0.0052 to 0.0079 (4.7 to 5.8) °	HP 8510C, test set 8515A, source 8340B, cables 85132F, cal kit 85050B
	(0.30 to 0.70) lin; (0.045 to 2.0) GHz	0.006 to 0.011 (0.68 to 0.98) °	
	(0.30 to 0.70) lin; (2.0 to 8.0) GHz	0.0063 to 0.0124 (2.4 to 2.6) °	

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Reflection Measurements (cont) – S11/S22, Magnitude & Phase			
Coaxial 7 mm	(0.30 to 0.70) lin; (8.0 to 18.0) GHz	0.0079 to 0.017 (4.6 to 4.7) °	HP8510C, test set 8515A, source 8340B, cables 85132F, cal kit 85050B
	(0.70 to 1.0) lin; (0.045 to 2.0) GHz	0.011 to 0.015 (0.62 to 0.68) °	
	(0.70 to 1.0) lin; (2.0 to 8.0) GHz	0.013 to 0.018 (2.4 to 2.4) °	
	(0.70 to 1.0) lin; (8.0 to 18.0) GHz	0.017 to 0.025 (4.6 to 4.6) °	
Coaxial 3.5 mm	(0 to 0.10) lin; (0.045 to 2.0) GHz	0.006 to 0.0065 (3.7 to 180) °	HP 8510 C, test set 8515A, source 8340B, cables 85131F, cal kit 85052B
	(0 to 0.10) lin; (2.0 to 8.0) GHz	0.0083 to 0.0088 (6.6 to 180) °	
	(0 to 0.10) lin; (8.0 to 20.0) GHz	0.0084 to 0.0089 (8.9 to 180) °	
	(0 to 0.10) lin; (20.0 to 26.5) GHz	0.0087 to 0.0091 (10.3 to 180) °	
	(0.10 to 0.30) lin; (0.045 to 2.0) GHz	0.0065 to 0.0086 (1.6 to 3.4) °	
	(0.10 to 0.30) lin; (2.0 to 8.0) GHz	0.0088 to 0.012 (3.7 to 6.2) °	
	(0.10 to 0.30) lin; (8.0 to 20.0) GHz	0.0089 to 0.013 (6.1 to 8.5) °	
	(0.10 to 0.30) lin; (20.0 to 26.5) GHz	0.0091 to 0.013 (7.4 to 9.8) °	
	(0.30 to 0.70) lin; (0.045 to 2.0) GHz	0.0086 to 0.016 (1.2 to 1.6) °	

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Reflection Measurements (cont) – S11/S22, Magnitude & Phase			
Coaxial 3.5mm	(0.30 to 0.70) lin; (2.0 to 8.0) GHz	0.012 to 0.024 (3.3 to 3.7) °	HP8510C, test set 8515A, source 8340B, cables 85131F, cal kit 85052B
	(0.30 to 0.70) lin; (8.0 to 20.0) GHz	0.013 to 0.027 (5.9 to 6.1) °	
	(0.30 to 0.70) lin; (20.0 to 26.5) GHz	0.013 to 0.027 (7.1 to 7.3) °	
	(0.70 to 1.0) lin; (0.045 to 2.0) GHz	0.016 to 0.023 (1.2 to 1.6) °	
	(0.70 to 1.0) lin; (2.0 to 8.0) GHz	0.024 to 0.038 (3.5 to 3.3) °	
	(0.70 to 1.0) lin; (8.0 to 20.0) GHz	0.027 to 0.044 (6.2 to 5.9) °	
	(0.70 to 1.0) lin; (20.0 to 26.5) GHz	0.027 to 0.044 (7.4° to 7.1)	

VII. Ionizing Radiation and Radioactivity

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Gamma Radiation – Measure			
Gamma Radiation Sources	20 μ R/hr to 10 000 R/hr	4.5 %	Shonka-Wycoff ionization chambers with Cs ¹³⁷ and Co ⁶⁰ sources

VIII. Optical Quantities

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Spectral Transmittance – Measure (250 to 2500) nm			Varian Cary spectrophotometer model 500 scan with: neutral density filters
Transmittance	(0.001 to 0.1) To 0.9	0.012 0.027	
Wavelength	(240 to 650) nm	0.28 nm	Polystyrene film, SRM 1921a
Wavenumber	(906.69 to 30 812.25) cm ⁻¹	2.3 cm ⁻¹	Perkin Elmer 2000 FTIR scan with polystyrene film, SRM 1921a
Wavelength	3267.94 nm	0.37 nm	Varian Cary spectrophotometer model 500 scan with polystyrene film, SRM 1921a
Fiber Optics – Measure			
Linearity 850 nm 1310 nm 1550 nm	(+3dbm to -60) dbm (2.5mW to 1μW)	0.016 db (0.18 %) 0.012 db (0.14 %) 0.013 db (0.15 %)	NIST triplet superposition system and method to calibrate fiber optic power
Power (Collimated) 850 nm 1310 nm 1550 nm	@ 100 μW	1.5 % 1.9 % 2.1 %	Judson IR fiber optic germanium detectors w/Anritsu model MS 9030A spectrum analyzer
Power (Connectorized) 850 nm 1310 nm 1550 nm	@ 100 μW	2.0 % 2.0 % 2.0 %	Agilent power meter model 8153A w/ Anritsu model MS 9030A spectrum analyzer

Parameter/Equipment	Range	Best Uncertainty ² (\pm)	Comments
Lasers – Measure, Calibration of Laser Power Meters High Energy	(50 to 1400) W (8 to 600) kJ	3.9 % 3.9 %	NIST designed calorimeter
UV Radiation – Measure Irradiance, at 365 nm	(0.5 to 2.5) mW/cm ²	7.3 %	Jerry Bachur Associates light source, LS90-NAFB

¹ This laboratory offers commercial calibration service.

² “Best Uncertainty” is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer’s device and to influences from the circumstances of the specific calibration.

³ In the statement of best uncertainty, L is the numerical value of the nominal length of the unit under test measured in inches or millimeters.